

# 2005 Annual Report



## LLNL role in LSST

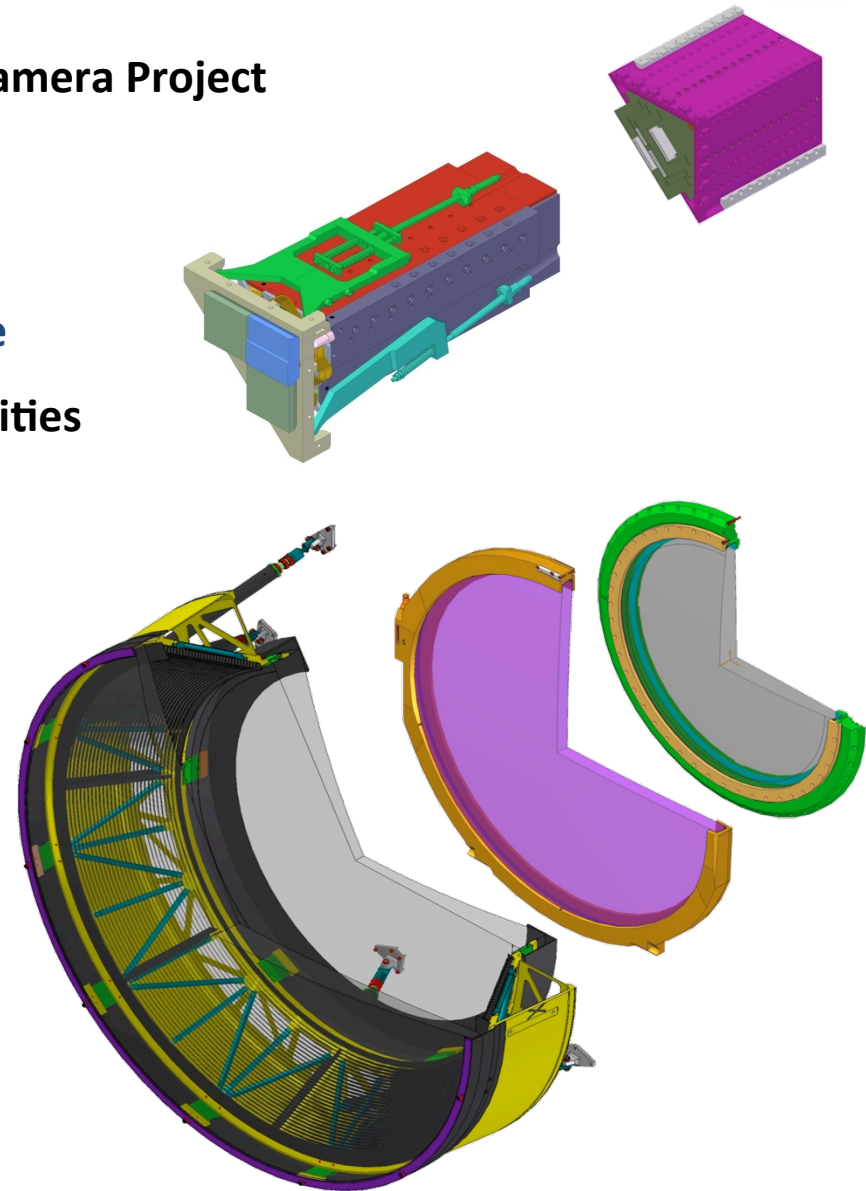
**William Goldstein**  
**Associate Director**  
**Physical and Life Sciences**  
**Lawrence Livermore**  
**National Laboratory**

**LSST DOE CD-1 Review**  
**November 1 - 3, 2011**

**Lawrence Livermore**  
**National Laboratory**

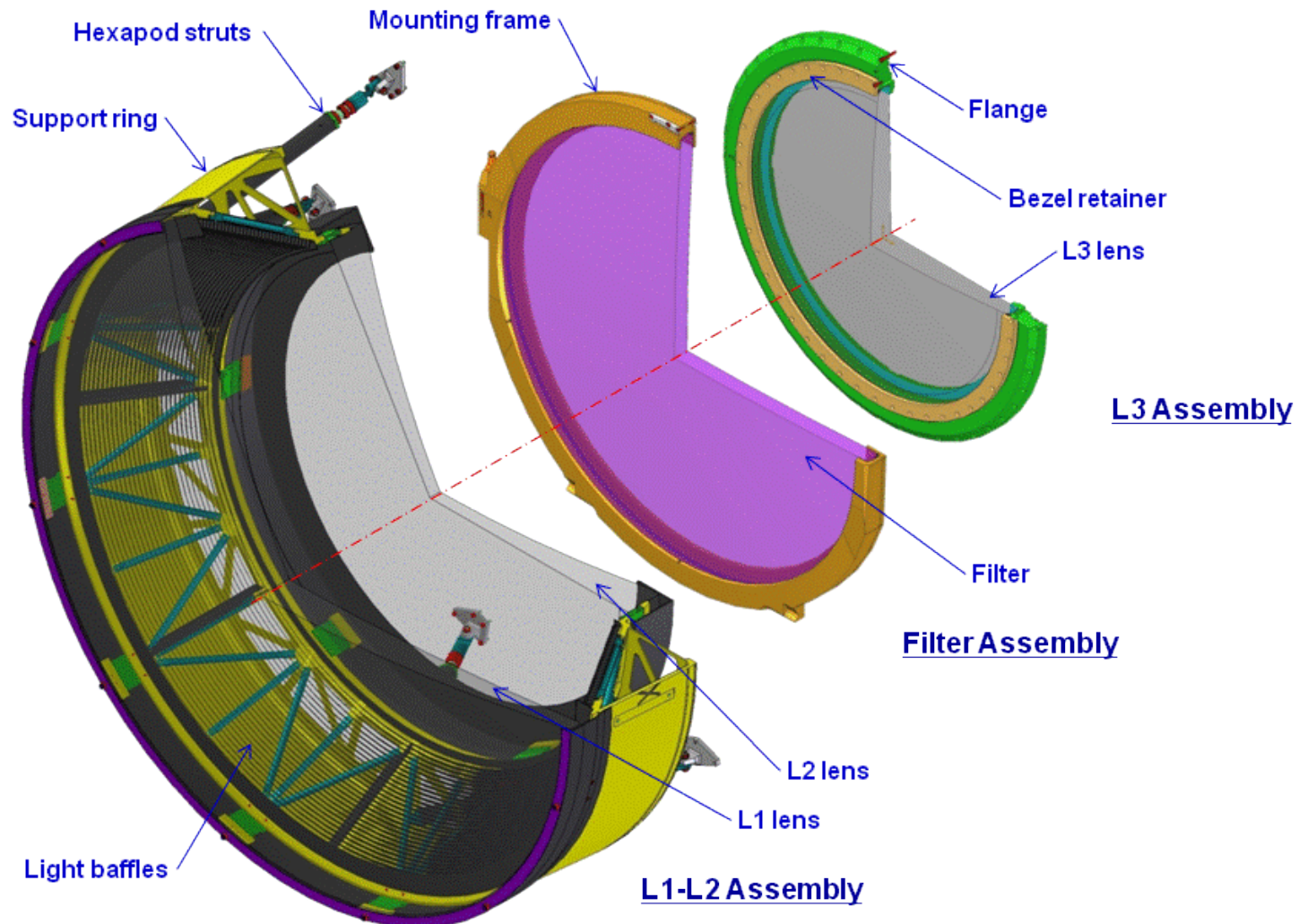
UCRL-TR-211126-05

- **LLNL technical responsibility in the LSST Camera Project**
  - Optics assemblies
  - Corner raft towers
  - LLNL team and management structure
- **LLNL commitments, contributions, capabilities**
  - Technical contributions to LSST R&D
  - Applied Physics Section
- **LSST and LLNL Strategic Plans**
  - LLNL and DOE High Energy Physics
  - History of LLNL involvement in LSST
- **Conclusions**

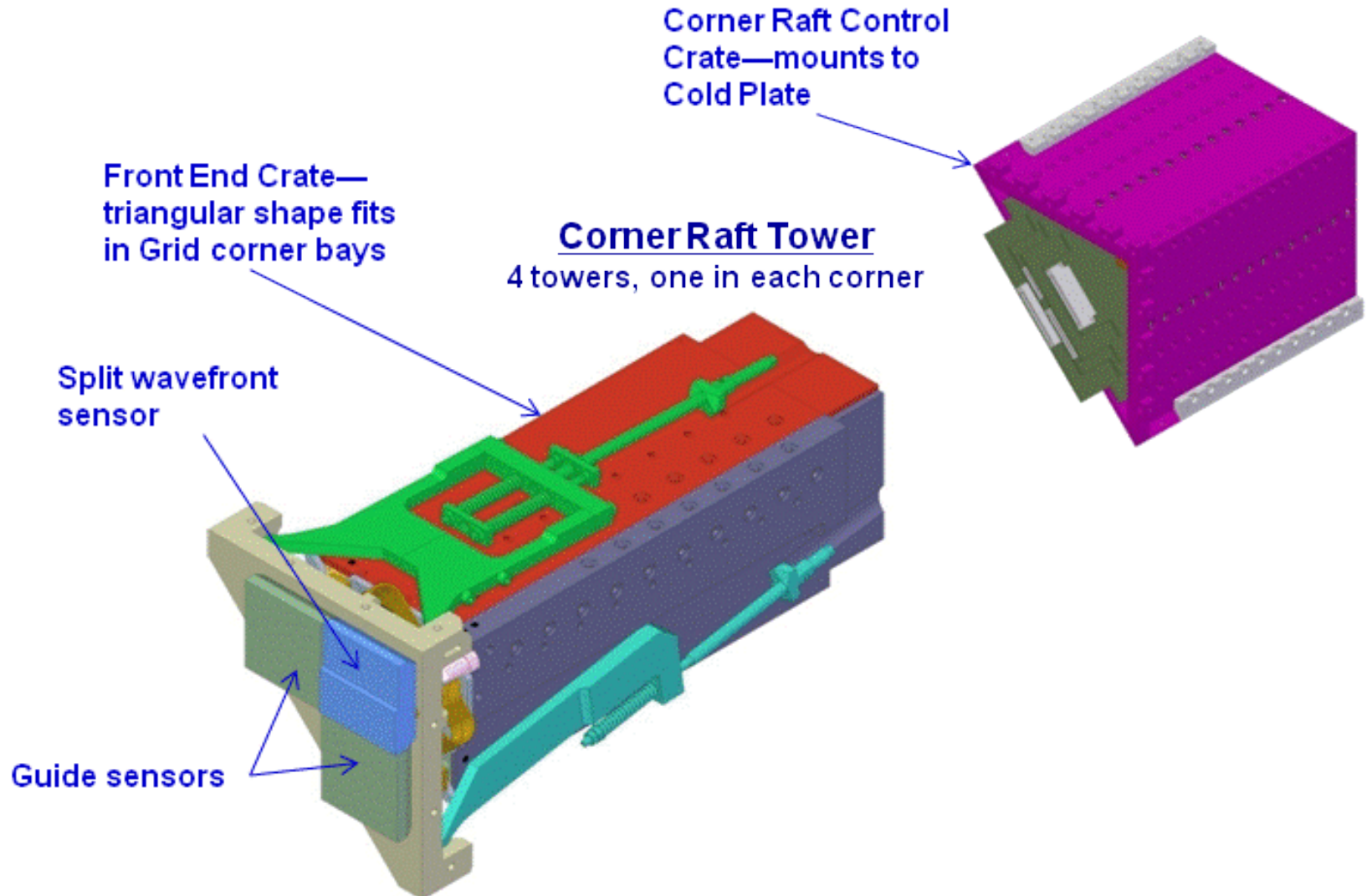




- L1-L2 Assembly (1)
- Filter Assemblies (6 – u, g, r, i, z, y)
- L3 Assembly (1)



- Corner raft towers (4)





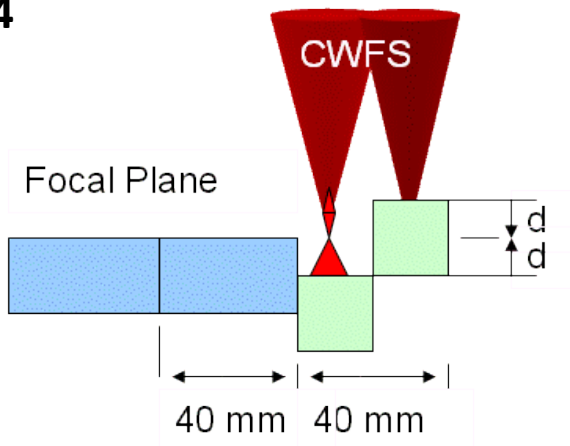
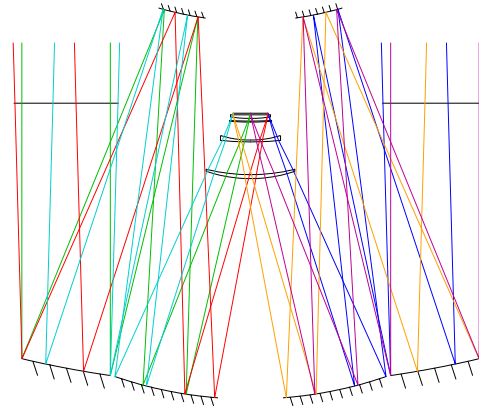


- **Present LLNL Core Team**
  - S. Olivier ( Physicist – Project Scientist)
  - V. Riot (EE – Project Manager, System Engineer)
  - B. Bauman (OE – Optical Designer)
  - S. Pratuch (ME – Opto-mechanical Engineer)
  - D. Carter (Mechanical Designer)
- **Core team can be augmented with experts from:**
  - Engineering Directorate
    - 1800 staff, including optical engineers, composite engineering, mechanical engineers, precision engineering, designers, project managers, engineering standards
  - Physical and Life Sciences Directorate
    - >800 staff, including optical science, material science, computational science, high energy physics, astronomy and astrophysics
    - Physics Division, Applied Physics Section
- **Project Management Support**
  - Extensive project tracking and reporting infrastructure, including formal internal monthly reporting to senior management
  - LLNL Procurement
    - Experience procuring >1000 meter-class optics in the past decade for the National Ignition Facility
  - Dedicated LLNL Resource Analyst Staff

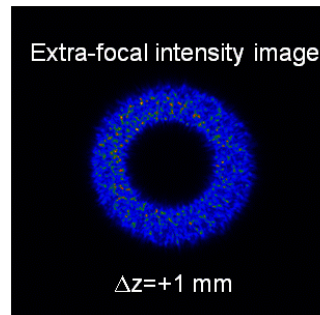
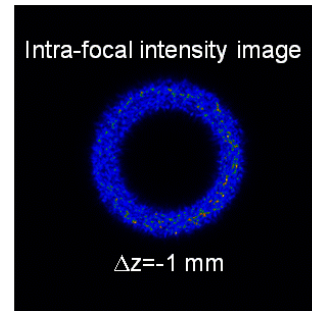
# LLNL has made numerous contributions to conceptual design of LSST camera over the past decade



- LLNL has worked on the optimization of the LSST optical design since 2001
- LLNL has worked with multiple optics vendors since 2004 to assess manufacturability, schedule and cost of LSST optics
- LLNL has worked on design and analysis of the wavefront sensors and guiders since 2004



[Curvature wavefront sensor geometry](#)





## Applied Physics Section Mission

The Applied Physics Section carries out R&D in the areas of optics, x-ray science and technology, biophotonics, and space science for applications throughout LLNL's mission areas.

### Capabilities

- **X-ray science and technology**
- **Optics and imaging**
- **Biophysics and Biophotonics**
- **Instrumentation and Sensors**
- **Advanced Detectors**
- **Data analysis and algorithms**

### Applications areas

- **Space science and astrophysics**
- **High energy physics**
- **Stockpile Stewardship**
- **Non-proliferation and counterterrorism**
- **Fusion energy**



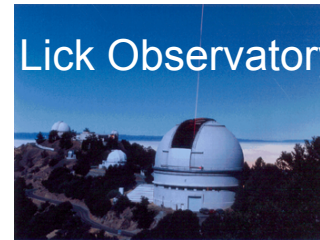
## Center for Adaptive Optics at UCSC



University Partnerships, Students, Post-docs

## Pioneering Astronomical Systems

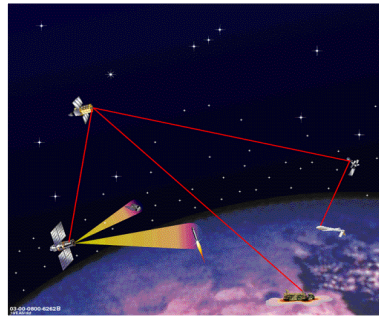
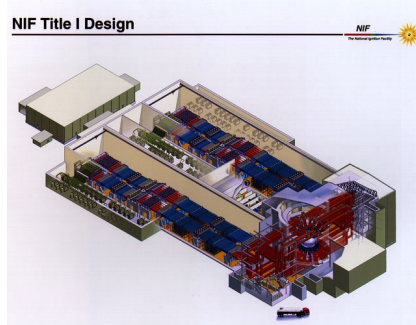
Lick Observatory



Keck Observatory

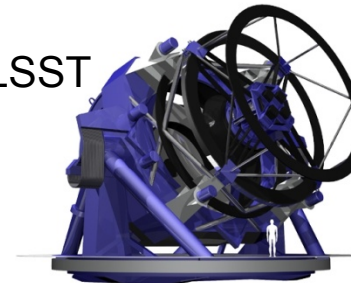


Laser Guide Star Adaptive Optics

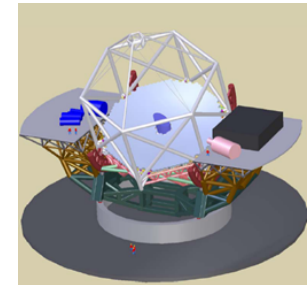


Advanced beam control systems

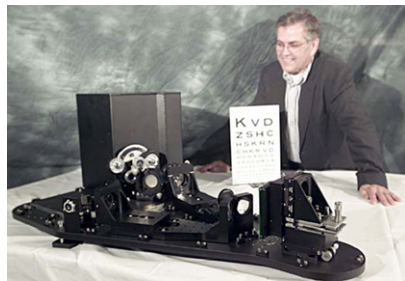
LSST



TMT

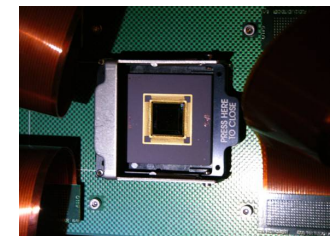
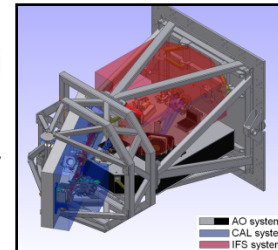


Next Generation Telescopes



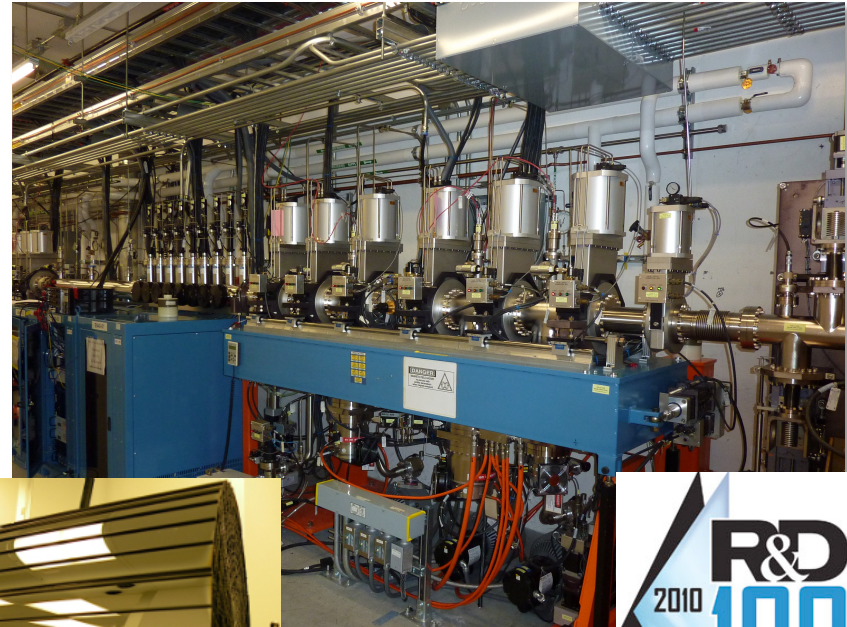
Award-winning ophthalmic instruments

Gemini Planet Imager



Advanced instruments & technology

## LCLS Beam Energy Monitor



## X-ray Optics

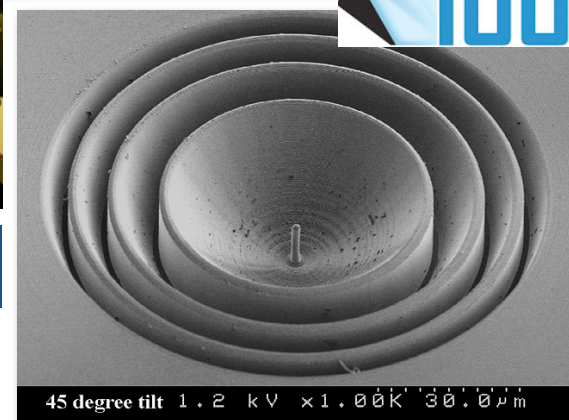
- Design
- Fabrication
- Characterization and Metrology

## Applications

- LCLS, XFEL, FERMI, etc.
- Solar Dynamics Observatory
- NuStar space telescope
- NIF



NuStar Optics  
Module

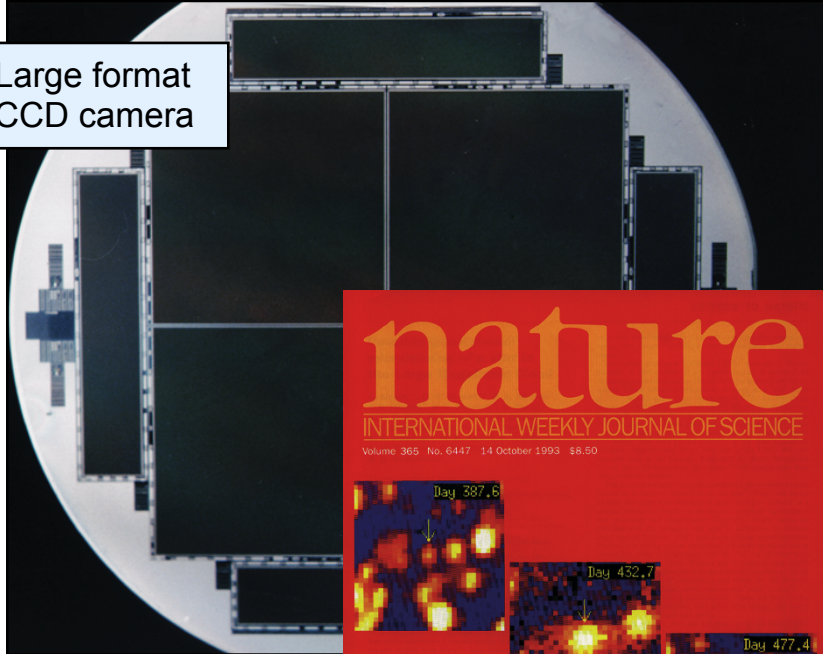


Survivable X-Ray Lenses  
Beryllium Fresnel zone plate



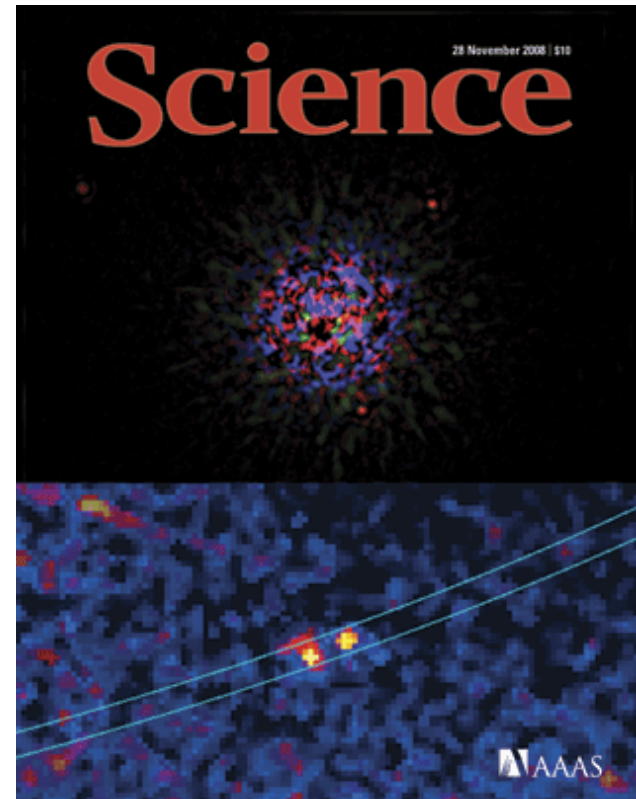
## MACHO microlensing survey; First discovery of dark matter

Large format  
CCD camera



Alcock et al.

## Keck Adaptive Optics capture First images of extra-solar planetary system

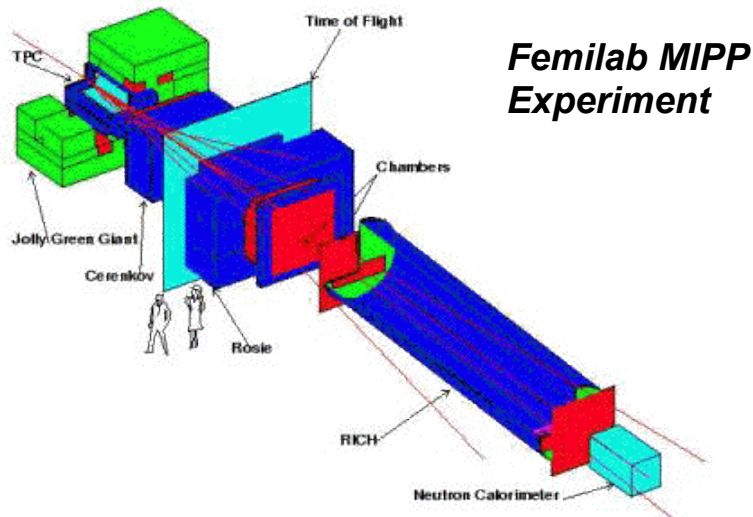


Marois et al.

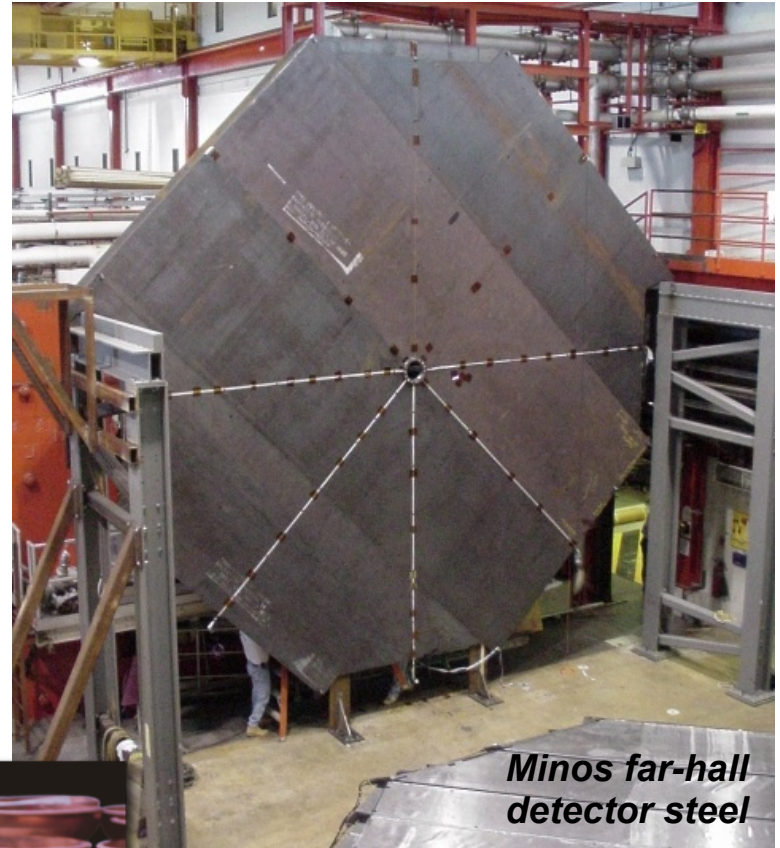
**LLNL pioneered digital, wide-field, time-domain astronomy**



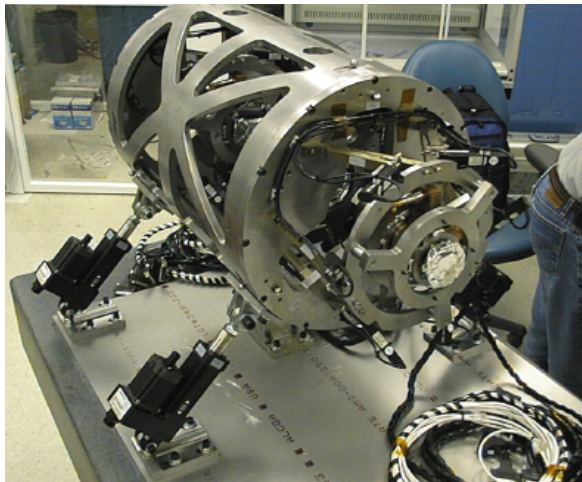
# LLNL has contributed unique capabilities to Office of High Energy Physics projects



*Femilab MIPP Experiment*



*Minos far-hall detector steel*

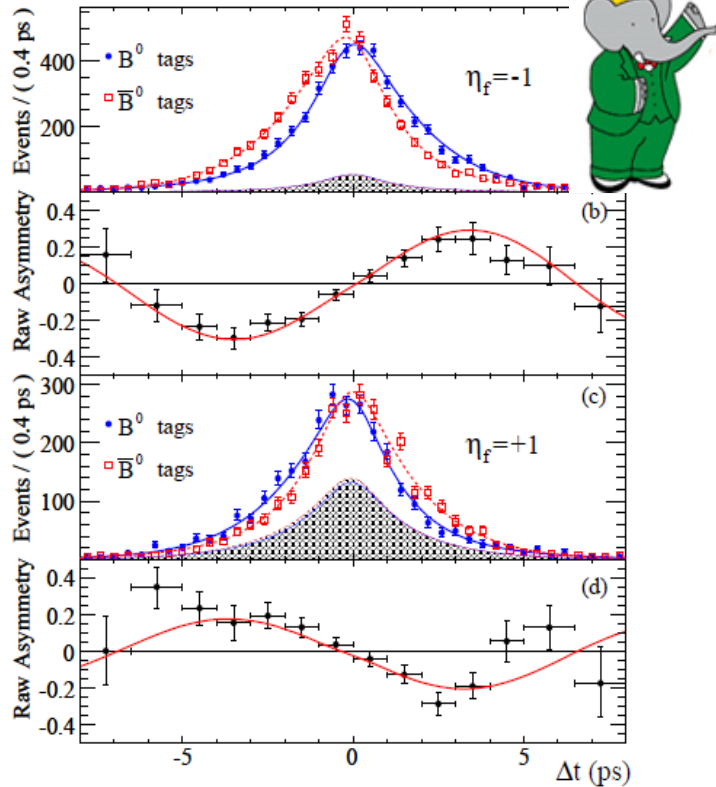


*Nano-beam positioning test stand for the ILC*

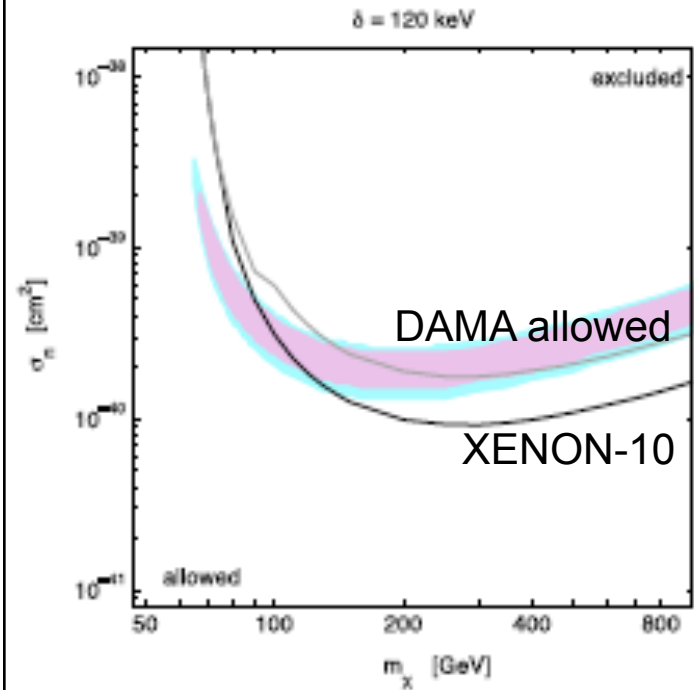


*B-Factory RF cavities*

## BaBar



## XENON

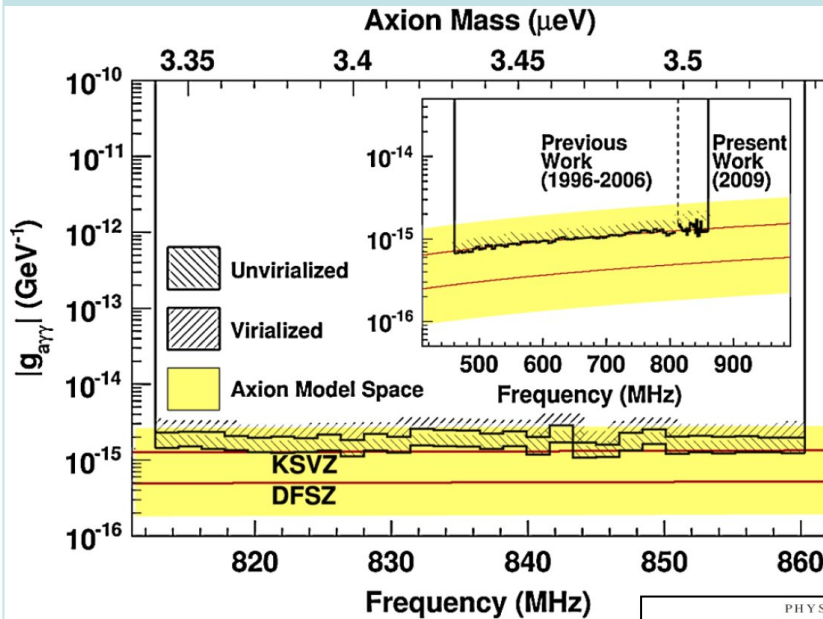


PR D 80, 115005 (2009)

# ADMX - successful construction and operation of SQUID amplifier upgrade



Phase I upgrade complete FY08 data run began in May 2008 completed May 2010 PRL on Axion search limits and other light bosons



ADMX moved to University of Washington to prepare for Upgrade II (dilution refrigerator). LLNL continues to collaborate.

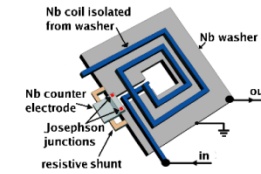


FIG. 2: Schematic of a microstrip SQUID amplifier.

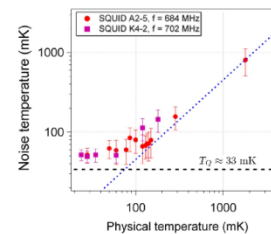
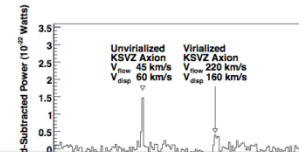


FIG. 3: Noise temperature of two representative SQUID amplifiers with resonant frequency  $f$  as a function of physical temperature. Dashed line indicates  $T_Q$ , the quantum noise temperature at  $\approx 700$  MHz. Dotted line has unity slope, indicating that  $T_A \propto T$  in the classical regime.



APPLIED PHYSICS LETTERS 92, 172503 (2008)

## Microstrip superconducting quantum interference device radio-frequency amplifier: Scattering parameters and input coupling

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 (Received 9 February 2008; accepted 5 March 2008; published online 29 April 2008)

## Measurement of the Josephson Junction Phase Qubits by a Microstrip Resonator

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## Abstract

The process of measurement of a phase qubit by a resonant microwave cavity is considered for various interactions between the qubit and the cavity. A novel quasiclassical approach is described based on adiabatic reversals of the qubit state by an effective field. A similar approach was implemented earlier for the detection of electron and nuclear spins using magnetic resonance force microscopy (MRFM), but this approach has not previously been used for the measurement of a quantum state. Quasiclassical and quantum regimes are described. We consider both linear and nonlinear resonators. The effects of the environment on the process of measurement are also analyzed.

## I. Introduction

Superconducting Josephson junctions are now considered as the most realistic candidates for solid state qubit implementation. (See, for example, Refs. [1-4].) The research in this field is

## SQUID-Based Microwave Cavity Search for Dark-Matter Axions

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 (Received 27 October 2009)

Axions in the  $\mu\text{eV}$  mass range are a plausible cold dark-matter candidate and may be detected by their conversion into microwave photons in a resonant cavity immersed in a static magnetic field. We report the first result from such an axion search using a superconducting first-stage amplifier (SQUID) replacing a conventional GaAs field-effect transistor amplifier. This experiment excludes KSVZ dark-matter axions with masses between  $3.3 \mu\text{eV}$  and  $3.53 \mu\text{eV}$  and sets the stage for a definitive axion search utilizing near quantum-limited SQUID amplifiers.

DOI:

PACS numbers: 95.35.+d, 14.80.Va, 95.55.Vj

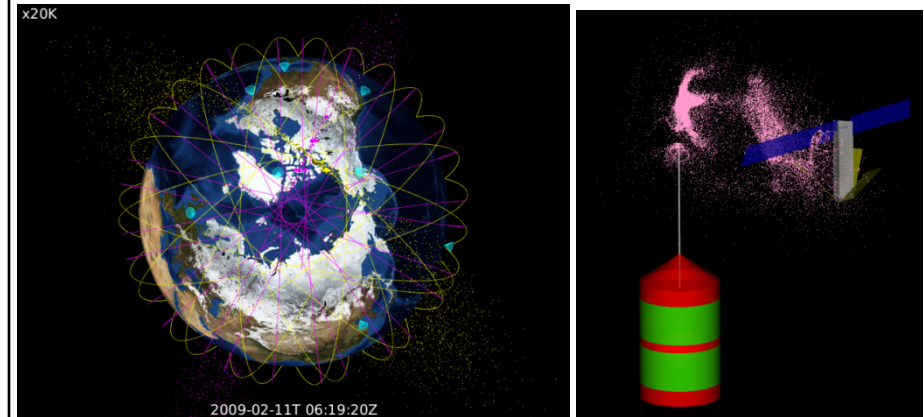


# Participation in LSST has significant strategic value to LLNL



- **Work leverages and enhances LLNL capability**
  - Astrophysics, nuclear physics, astronomy and cosmology
  - Image processing, real-time, data-intensive computing, large scale simulation and modeling, super computer architectures
  - Optical engineering and technology
- **Activities foster and maintain important strategic collaborations**
  - University of California, SLAC
  - Google, Microsoft, NCSA
  - NOAO, Large optics industry
- **Optical and information S&T developed as part of LSST directly relevant to national security applications**

## Space Situational Awareness



- Simulations of debris generation from orbital impacts enabling:
  - Assessment of risk to active satellites
  - Satellite repositioning strategies
  - Optimal sensors schedule
- New methodologies for real-time data fusion and prioritized sensor cueing
- Optimized technology development strategies for achieving required SSA network performance
  - New sensor concepts to detect and track smaller objects

# **LLNL Commitment to LSST;**

## **LLNL was one of the 8 original LSST partners**

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- **2001 LLNL begins optimizing the LSST optical design**
- **2003 LLNL begins development of LSST cadence simulator**
- **2004 LLNL's Don Sweeney becomes LSST Program Manager**
- **2004 LLNL begins interactions with multiple optics vendors to assess manufacturability, schedule and cost of LSST camera optics**
- **2004 LLNL begins design and analysis of LSST wavefront control**
- **2004-2007 LLNL leads initial design of LSST data processing infrastructure and middleware, studies database design and data products**
- **2005-2006 LLNL studies the ability of LSST to measure galaxy shapes to detect weak lensing in the presence of atmospheric turbulence**
- **2007-2009 LLNL studies the use of LSST to measure photometric redshifts of supernova needed for cosmological analysis**
- **2010 LLNL hires Michael Schneider, expert in cosmological n-body simulations, to work on LSST science**

**LLNL contributions to LSST R&D over the past decade total >30 FTE-years**

- **LLNL has accepted the responsibility to deliver the Camera Optics and Corner Raft Modules.**
- **LLNL commitment to LSST is proven and long-term**
  - Many years of Lab support in the R&D stage of the project
  - Continued Lab support through Applied Physics and Engineering staff
- **LLNL responsibilities are well matched to Lab technical capabilities in large optics development and optical wavefront control**
  - LLNL has recently completed construction of the National Ignition Facility using >1000 large optics
  - LLNL has been a world leader in astronomical adaptive optics for the past 2 decades
- **LSST is aligned with LLNL scientific interests in high energy physics and with LLNL programmatic interests in space security and intelligence**





**End of Presentation**

